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ABSTRACT

Presented as part of a larger unit on watershed investigations are a slideshow script and a map and compass unit intended to help high school students better visualize the relationship between a water sampling site, the entire stream, community, and watershed. The script discusses features of a topographical map, shows how to read one, and demonstrates several mapping exercises involving mapping tables, clinometers, photo maps, and topographical models. Part two elaborates on the topographical map information presented in the slideshow. Also discussed are compasses and how to use them. Several map and compass exercises are included. Appendices provide information for purchasing compasses and teaching aids. (DC)

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SITE AND WATERSHED MAPPING

Part I - Procedures - Transcript of Tape Cassette

Pert II - Procedures - Supplement

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SITE AND WATERSHED MAPPING

- In earlier filmstrips you have learned to investigate the chemical, physical, biological and bacteriological characteristics of a stream in your neighborhood. You have learned that water in the stream is, in large measure, a reflection of the stream's watershed.
- This filmstrip will introduce you to an investigative activity that lets you visualize the relationship between your sampling sites, the entire stream, your community and the watershed. You are going to learn how to use and how to make maps.
- The Institute for Environmental Education presents:
- Site and Watershed Mapping.
- There are many kinds of maps. This is a braille map of London for use by the blind. Everyone that wants to know where they are or wants to know how to get to where they are going, needs a map whether they are geologists, astronauts, sailors, or picnickers.
- Your teacher already has the topographic maps of your area and you have had a chance to become acquainted with them. These maps are made by the Cartographic Section of the U. S. Geological Survey in Denver, Colorado.
- They showed us how a map maker etches each line on the map. No machine can duplicate the skill of this man's hands as he intreprets projected elevations into contour lines.
- Students in the "Cuyahoga Watershed Project" mounted all of the topo maps of their 813-square-mile watershed and have traced the streams and watersheds within their school district.
- Let's look carefully at a topo map. The bottom margin of this map shows that it has a scale of 1:24,000. This means that 1" or 1 centimeter on the map represents 24,000 of the same units on the ground. On the right side of the map is the quadrangle location--a black dot in the outline of the state that shows where in the state you are located. On the left side is the magnetic declination--the number

of degrees that a compass will vary from true north at your location. (The quadrangle location marked by a black dot cannot be seen in the film.)

- Beneath the scale is a statement of the contour interval. The contour interval on this map is 10'. O.K.--so what is a contour interval?
- All these lines that wiggle around on the map are contour lines. They may have been etched by the man from the Cartographic Section in Denver. Contour lines connect points of equal elevation. The spaces between the lines are contour intervals and are a measure of verticle (up and down) distance. The smaller the countour interval, the steeper the terrain.
- This picture shows the Middle and Grand Teton Mountains in Wyoming. You can see Teton Glacier between the two mountains. Try to fix the shape of the mountains in your head for a second and compare them to:
- This picture of a topographic map of the same mountains. Notice the glacier and see how you can get an idea of the shape of the mountains from the design of the contour lines.
- The topo map also shows roads, houses, your school and many other bits of information. This slide shows a school (1) in purple to the left of a paved secondary road, a heavy duty highway (2) turns from one lane to two nearby a wooded ravine (3) behind the school where a sampling site has been established at the intersection of the penciled lines. Across the road a large orchard (4) is identified by the green dots. Just north of the school notice the triangle in the road (5). This is a triangulation point for surveying. There are also the letters BM and the numbers 976. This indicates a bench mark with an elevation of 976' above sea level.
- An actual bench mark looks like this. Look at your map and find where one is located near your school and then take a field trip, using your map to guide you to the exact location and a small marker like this one. First let's look at the map a little more.
- At each corner of the map you will notice numbers followed by a circle, a dash and then two dashes. The circle means <u>degree</u>, the single dash, <u>minutes</u>, and the double dash, <u>seconds.</u> There are 60 seconds in a minute and 60 minutes in a degree.

The numbers centered on the horizontal base of the map indicate the latitude--the numbers centered on the verticle side indicate the longitude. The latitude along the base of this map is 41° 37' 30" and the longitude is 81° 07' 30". In North America latitude measures how far we are north of the equator and longitude measures how far west you are from the zero meridian in Greenwich, England.

- This sign in Yellowstone National Park tells an interesting story. 45° latitude also passes just north of Salem, Oregon on across Idaho, Wyoming, and South Dakota through Minneapolis, Minnesota and becomes the boundary of the U. S. and Canada at New York and Vermont. How many degrees of latitude is your school from the halfway point between the Equator and the North Pole?
- To find the exact latitude and longitude of your stream sample site draw pencil lines through the point at exact right angles to the sides of the map.
- To find the longitude, use your metric ruler to measure the distance from the point where the pencil line touches the top or bottom of the map to the nearest given longitude, in this case 81° 10'. We found that it is 7.2 mm from this mark to the pencil line.
- 3 mm equals approximately one minute of either latitude or longitude. By dividing 3 into 7.2 we get 2' with 1.2 mm left over. We then multiply the 1.2 by 20 to find a quotient of 24". Add the 2' 24" and the 8° 10' together to find a longitude of 81° 12' 24". Go over this in class several times. Your teacher will explain why you multiply by 20.
- Use the same technique to find latitude. Measuring up from 41° 37' 30" to the horizontal pencil mark, we find 11.4 mm or 3' 48". This substracted from 41° 37' 30" comes to 41° 33' 42". Work this out for yourself on a piece of paper. There is a full explanation in the Learning Kit.
- When you have determined the latitude and longitude of your site, record it on your data sheet. The latitude and longitude of sample sites is important information, since regulatory agencies identify sites in this way. In order for your data to be useful to them you must know the exact location of the site.

- Now that you have the latitude and longitude you will want to get a larger picture of the area. You can do this by transferring the information from the topo map to a base map grid. This technique is borrowed with permission from procedures developed by The Nature Conservancy.
- Tape the map flat and place the acetate overlay grid from the Learning Kit over the area you wish to transfer.
- Use the proper grid and try to include your entire watershed within the grid. Now carefully transfer the important features from the topo map on the enlarged grid sheet.
- After making this rough working sketch of the area, these students decided to make a large-scale, accurate map for a vegetational analysis. This student is using a procedure known as plane table mapping.
- The first step begins with the construction of a Mapping Table. This is merely a sheet of heavy plywood that can be leveled and moved about. Follow instructions in the Learning Kit.
- These instructions are taken from "A Curriculum Activities Guide to Water Pollution Equipment and Environmental Studies" published by the Institute for Environmental Education and written by David Kriebel and Tim Tanaka while they were high school students in Pennsylvania. There are 19 student-made devices for environmental investigations described in this useful publication.
- Assemble a large sheet of poster board, a yardstick, pencils and the tag line used in flow studies. Tape the paper to the Mapping Table and level it at a point--base point A. Indicate this point on the paper--drive a stake at another point exactly 100' away and measure 10" on the paper--label this base point B. The scale of your map will be 1.120 or 1" on the map equals 120" on the ground or 1" on the map equals 10' on the ground.
- Drive other stakes at a number of strategic points. Sight along the yardstick toward each stake and draw a line on the paper in direct line.

- Move the Map Table to base point B. Level it and repeat the steps above. Darken the intersection points. Erase the construction lines and connect the points. If you cite accurately, have a level table, and exactly 100' between A and B, your map should be to scale. Check distances by pacing off from points A and B.
- Here is the map with construction lines shown. The circles show the beginning of a survey of trees. The letters identify the species,and the numbers the diameter is at breast height.
- You can now go one step further if you like. Follow the instructions for building and using a clinometer in the "Guide to Water Pollution Equipment." With this you can plot elevations on your map and come up with your own large scale topographic map.
- Another very exciting way of looking at your community is with a photo map taken from a satellite. Every 18 days the Earth Resources Technology Satellite passes over you 567 miles high and takes a picture. You can get this picture which encompasses 115 square miles for $1.75.
- An inquiry form and instructions on obtaining this and other pictures from space are included in the teacher's materials. You can get Skylab, NASA Aerial photos and Gemini-Apollo photos that were taken from altitudes from 2,000',to some taken from the moon. Some students set up a bulletin board in their school with a display of maps of the community showing sampling sites and data from these sites.
- Another very good mapping exercise is the construction of topographic models of watersheds which have been developed by Jack Arnold and his students at Berkshire High School in Burton, Ohio. This procedure has students trace their stream on a topo map, then locate stream watershed by outlining the contour line of highest elevation.
- Then take a picture of the area with a camera equipped with close-up lens. This picture is developed and projected to the desired size on a sheet of paper.
- Contour lines are carefully traced onto the paper and look like this.
- With careful scissor work, each contour interval is cut out and mounted on card-

board with rubber cement. The contour line becomes a guide for cutting out a cross section of the watershed.

- Then sectioned layers are glued together and stacked to make a rough three-dimensional model of the watershed.
- Next dissolve wallpaper paste in water and soak newspaper strips in the mixture.
- Carefully lay these newspaper strips over the cardboard model and use a pointed dowel to lightly etch water courses.
- After the model has dried, paint it with a primer such as Gesso.
- Several coats provide a smooth base and an attractive product.
- It is then a good idea to paint in roads, buildings, lakes, streams, and wooded areas.
- Some students then learn about the geology of the area from the Soil Conservation Service and label each formation on the cross-section of the watershed.
- The finished product is an excellent tool to use in understanding topography and physical relationships within a community. The students from Berkshire used this map and the water quality data that they had collected to explain the impact of a proposed trailer park to the local planning commission.
- You may now begin to practice these mapping techniques to become better acquainted with your community. As you begin each project, review the procedures in this filmstrip and refer to the learning kit for specific details.

PART II - TOPOGRAPHIC MAPS AND COMPASS USE

TOPOGRAPHIC MAPS[1]

A topographic map is a line-and-symbol representation of natural and selected man-made features of a part of the Earth's surface plotted to a definite scale. A distinguishing characteristic of a topographic map is the portrayal of the shape and elevation of the terrain by contour lines.

The physical and man-made features of the terrain, as determined by precise engineering surveys and field inspection, are recorded on the map in a convenient, readable form. Topographic maps show the location and shape of mountains, valleys, and plains; the networks of streams and rivers; and the principle structures, such as schools, museums, and reservoirs.

Map scale defines the relationship between the measurements of the features as shown on the map and as they exist on the Earth's surface. Scale is generally stated as a ratio or fraction--1:24,000 or 1/24,000. The numerator, customarily 1, represents map distance, and the denominator, a large number, represents horizontal ground distance. Thus the scale 1:24,000 states that any unit, such as 1 inch or 1 centimeter on the map represents 24,000 of the same units on the ground.

Maps are classified generally by publication scale, and each scale series fulfills a range of map needs. The Topographic Map Series of the USGS National Mapping Program includes quadrangle and other map series published by the Geological Survey. A map series is a family of maps conforming generally to the same specifications or having some common unifying characteristic such as scale. Adjacent maps of the same quadrangle series can be combined to form a single large map.

Series	Scale	One Inch Represents	Standard Quadrangle Size (Lat. & Long.)	Quadrangle Area, sq. mile
*7.5'	1:24,000	2,000	7.5' x 7.5'	49 to 71
15'	1:62,500	app. 1 mile	15' x 15'	197 to 282
Intermediate	1:100,000	over 1.5 mile	30' x 1°	1,145 to 2,167
US	1:250,000	app. 4 miles	1° x 2°	4,580 to 102,759

*60'=1°

Note: Maps of Alaska and Puerto Rico have different scales.

The National Mapping Program includes other special purpose maps and related data, such as Orthophotomaps (color photographs as opposed to line maps), county maps at 1:50,000 and 1:100,000 scale, and state base maps at 1:500,000 and 1:1,000,000 scales.

Horizontal and vertical ground surveys are used to present map features in correct relative position. For horizontal reference, latitude and longitude of selected points within the area to be mapped are determined by field surveys. Vertically, elevations of selected points are also measured in the field. These permanent, or "monumented," control points are called "bench marks"; they are usually metal tablets 2 to 4 inches in diameter prominently displayed in rock or masonry or on driven metal rods. Many are shown by symbols on the map itself. A single mark may serve both horizontal and vertical reference points.

Mapping procedures are primarily photogrammetric, using aerial photographs and complex stereoscopic plotting instruments. An aerial camera records the terrain from thousands of feet above in a planned series of overlapping exposures. The resulting photographs are viewed as pairs through a plotting instrument having an optical system that causes the left eye to see one photo and the right eye to see the other. The view is a three-dimensional stereo model of the terrain from which the compiler can precisely delineate contours, drainage, woodland, and structures. Shadowed or obscured features are plotted from the ground, while place names and political boundaries are verified; public land corners located; and roads, water features, and buildings classified by ground inspection, either before or after the map manuscript is compiled from the photographs.

Final cartographic processing and editing are required for the preparation of plates for printing. The paper formerly used for map compilation has been replaced by a thin, paint-coated plastic. Exceptionally stable as a base, the film can be engraved

or etched by using special scribing tools and a light-table. As a first step from compiled manuscript to finished map, the linework is reproduced photo-chemically on several plastic sheets. These are used to prepare a series of scribed sheets, each containing map detail of a single color. For lithographic printing, a press plate is made for each color by exposing the corresponding scribed sheet. Before the final run, a proof copy of the map is carefully edited for content, legibility, accuracy, and spelling.

Symbols are the graphic language of maps--their shape, size, location, and color all have special significance. On Geological Survey maps water features are blue; man-made objects are shown in black; green distinguishes wooded areas from clearings; contour lines are brown. Water features are classified as perennial or intermittent. "Perennial" water features contain water throughout the year (except for infrequent periods of drought) and are shown by solid lines; "intermittent" features contain water only part of the year and are indicated by broken lines. Single lines represent streams, canals, and ditches less than 40 feet wide on 7.5-minute maps or less than 80 feet on 15-minute maps. The blue line marking the limits of the coastal water represents approximate mean high water, always at a higher level than the zero reference for contours. Heavily built up areas larger than three-quarters of a square mile are shown with pink-tint overprint. In these areas, the only buildings shown are landmark structures such as schools, churches, public buildings, and others that are prominent because of size, design, or historic interest. The limits of these tinted areas relate to the density of construction, not to political or legal boundaries.

Red represents or emphasizes map features, such as the more important roads, route numbers, fence lines, land grants, and the demarcation between townships, ranges, and sections in the States subdivided by public-land surveys. Public-land lines and civil boundaries (shown in black) are mapped as accurately as possible on the basis of information obtained from documentary records and field investigations. The lines

shown on the map are not intended to serve as definitive evidence of land ownership or boundary locations.

Geographic names are an important part of a quadrangle map. Much effort is spent in establishing correct map nomenclature based primarily on current local usage. Name controversies are resolved by the U. S. Board on Geographic Names, established by law to determine the choice, spelling, and application of geographic names on maps and documents published by the U. S. Government.

Map margins define the map's perimeters and provide needed explanations. The marginal information corresponds to the table of contents and introduction of a book, telling how that map was made, who prepared it, where the geographic unit is located, when it was compiled, and (if so) when revised. For examples of these, see the Limaville, Ohio map margin reproduced on the following page.

The lines of longitude (meridians) represent true north and south (not magnetic north and south) with reference to the planimetric (map) detail. Magnetic compass bearings, however, must be corrected for local variations as indicated by the declination diagram on the lower map margin. The angles in the diagram show the relative directions of true, magnetic, and grid north; therefore, the angular values given in figures are used for corrections. Magnetic declination is continually changing, so that the value applies only for the year specified.

You can measure the current magnetic declination readily and accurately in your locality. By orienting (aligning) the map along a straight road, or two distant map features away from local magnetic interference, a corrected figure for magnetic declination can be determined and written over the value given in the map margin. It is possible that magnetic north will vary significantly across your map, depending on its scale. There is no better way to obtain the local magnetic declination. Anything else published is an approximation of this method. Use of declination in

INTERIOR-GEOLOGICAL SURVEY WASHINGTON D C-1961-MB

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ROAD CLASSIFICATION

Heavy-duty	———	Light-duty	———
Medium-duty	———	Unimproved dirt	.....
U. S. Route		State Route	

QUADRANGLE LOCATION

LIMAVILLE, OHIO

NW/4 ALLIANCE 15' QUADRANGLE

N4052.5—W8107.5/7.5

1960

map reading and field sighting follows this section.

Maps are revised periodically to meet the changing needs of map users. The newest revision technique used by Geological Survey consists in updating map content without field investigation. Changes interpreted from current aerial photographs are overprinted on purpose, so that the revised map also provides an historical comparison of development. The photo revision technique is a fast and efficient means of keeping maps as current as possible.

Indices showing topographic maps published for each State, Puerto Rico, the Virgin Islands of the U. S., Guam, and American Samoa are obtained free on request from the Branch of Distribution, U. S. Geological Survey, 1200 South Eads Street, Arlington, Virginia 22202; or Branch of Distribution, U. S. Geological Survey, P. O. Box 25286, Federal Center, Denver, Colorado 80225. The indices contain lists of special maps, addresses of local map reference libraries, local map dealers, and Federal map distribution centers. An order blank and detailed instructions for ordering maps are supplied with each index.

Mail orders for State maps may be sent to the Arlington address for areas east of the Mississippi River, or to the Denver address for areas west of the River. Payment may be made by money order or check payable to The Geological Survey. A copy of the Denver "map order blank" is in Appendix A.

NCIC, the National Cartographic Information Center, provides a national information service on maps, charts, aerial and space photographs, geodetic control, and other cartographic data for the United States. NCIC is able to inform the customer what data are available, identify what agency holds the data, and provide instructions on placing orders.

For more details, contact the National Cartographic Information Center, U. S. Geological Survey, 507 National Center, Reston, Virginia 22092, (703) 860-6045.

USING A COMPASS

You will need a USGS topographic map and a compass. From information given above, you can obtain USGS map indices, the addresses of local map reference libraries, and local map dealers. Probably your neighborhood book stores carry the maps; you should be able to select several that include your study area.

Compasses also are readily available and in several forms. In the following book, Be Expert with Map & Compass: the "Orienteering" Handbook by Bjorn Kjellstrom, you will find a map, a practicing compass, and a practicing protractor. Additionally, the book contains information on Silva instructional devices (we include in Appendix 1 descriptive information about Silva products, although we intend no endorsement of them).

The demonstration (not real) compass furnished with the book has a transparent base plate fastened to the bottom of the compass case. This plate has an engraved line extending from the center, or north, which simplifies the placing of the compass on top of a map and aligning the north-south direction of the compass with the map grid lines. It is not essential to have this type of compass, but it is probably more accurate when working with topographic maps than a small, thick compass which stands well above the plane of the map, making alignment quite inaccurate.

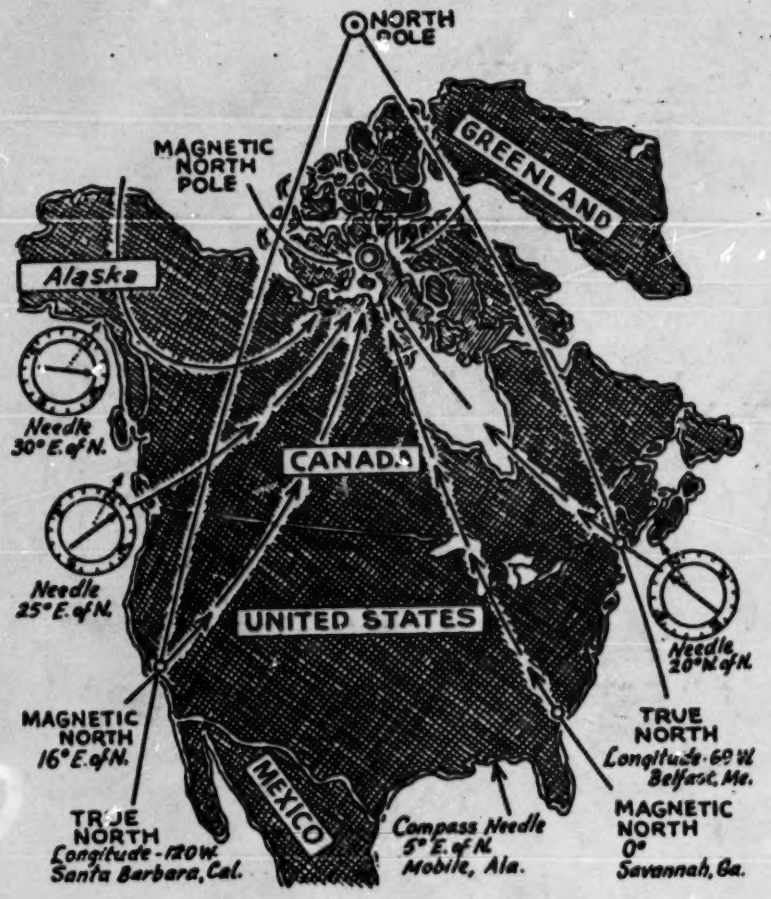
About 5,000 years ago, someone placed a piece of metal on a sliver of floating wood and was astonished to find the wood turned and aligned itself consistently in what is known as the north-south axis. The metal, which is magnetized, is oriented along magnetic force lines that seem to point into the Earth somewhere north of Canada and a good distance short of the axis line about which the Earth rotates, the North Pole. The north-seeking needle of a compass held sideways will actually point downward toward the Earth, more vertically nearer the magnetic north pole. In fact, if you were able to walk around the magnetic north pole, the compass' north end of the needle would point to that spot continuously, regardless of your position.

A Xerox copy of page 89 from Kjellstrom's book pictures this relationship. Page 91 shows the "declinations," or the path the magnetic needle will hold across the United States relative to the geographic North Pole. Note, for example, that in the State of Washington, the declination is about 25° east of the direction between the compass and the planimetric or true north pole. The effect on a compass is represented on the upper drawing: the needle points 25° to the east of the compass' north pole.

The point is this: If you started walking "north" from Washington by following your compass needle direction, you would really be walking toward central Canada, and not due north. If you started from Alaska, you can see that you would be walking quite sharply to the east of the real north. Or, to take an extreme situation, if you were between the magnetic north pole and the true North Pole, your compass needle would be point south of the magnetic north, precisely the opposite direction of true north.

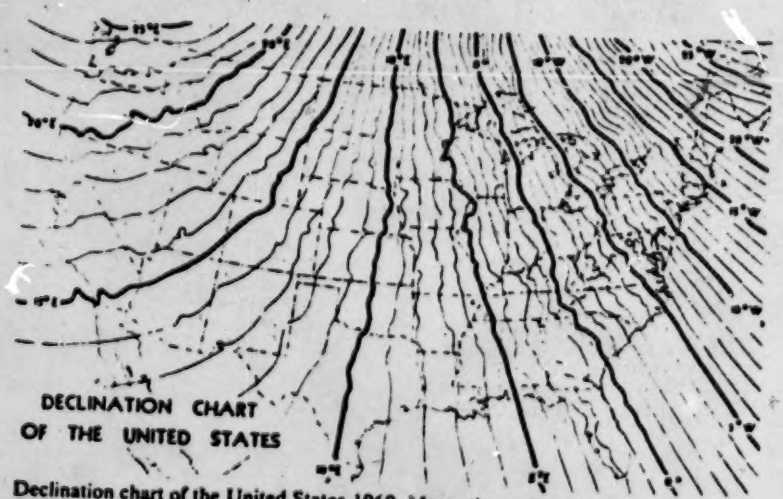
Except for a line of zero declination (along the east coast of Florida and up through Lake Michigan), your present geographic location will cause the magnetic needle to point to the right, east of true north (if you are on the Pacific side of Florida-Lzke Michigan), or left, west of true north (if you are on the Atlantic side of that zero-declination line). For this reason, when using a compass, you simply must compensate for the declination at that point.

Here's one way to compensate. Look at the Xerox of the map on the next page. Note the "Approximate Mean Declination, 1960" symbol at the bottom right hand corner. (This means that in 1960, the declination was calcualted. As we mentioned earlier, the magnetic north point shifts each year, and so it is not exactly the same now. But the shift is so slight that for practical purposes we can say that in using the map, the magnetic north pole is 4° to the left, or west, of true north.) Now, place the compass along the left margin, the north-south line of the map, so that the map line coincides with the imaginary line running from the compass' south, through its center, to the north. Leaving the compass on the map, turn the map clockwise until


NORTH POLE
MAGNETIC NORTH POLE
GREENLAND
Alaska
Needle 30° E. of N.
CANADA
Needle 25° E. of N.
UNITED STATES
Needle 20° W. of N.
MAGNETIC NORTH 16° E. of N.
TRUE NORTH Longitude - 120 W. Santa Barbara, Cal.
MEXICO
Compass Needle 5° E. of N. Mobile, Ala.
TRUE NORTH Longitude - 69 W. Belfast, Me.
MAGNETIC NORTH 0° Savannah, Ga.

True north is the map direction toward the geographical North Pole, magnetic north is the compass direction toward the Magnetic North Pole.

(1)



Declination chart of the United States 1960. Magnetic north and true north coincide on line east of Florida up through Lake Michigan. Other places have easterly or westerly declination.

(2)

[1] Kjellstrom, Bjorn, Be Expert with Map & Compass, the "Orienteering" Handbook, p. 89

[2] Ibid., p. 91.

the compass needle is 4° left of the coinciding map and compass meridian.

The reading on the compass is now 356°. Imagine the compass needle extending all the way to the Earth's magnetic north, while the map line extends all the way to true north. The map is now "oriented."

From now on, whenever you use a map and compass to relate map details with actual, outdoor details, first orient the map to take into account the real difference between magnetic and true north poles.

There are several variations to map and compass use. Teachers and instructional texts will probably show one or more of the variations; the principles are the same, however. For example, suppose that you wish to walk from the Church Campground to the intersection of French and Paris Avenues. You need to know the magnetic direction or azimuth, from the first to the second point. Here are two methods for obtaining the azimuth. First, orient the map, drawing a line from the more distant to the nearer point and through the lefthand meridian, as shown on the map preceding this page. Slide the compass down the meridian until the center of the compass is located directly over the intersection between the drawn line and the meridian--which you will have to do by estimation. Turn the compass, but not the map, counterclockwise until the needle points at the compass' north marker. Then, sight through the center of the compass down the drawn line and estimate the compass reading, or heading. Try it--after orienting the map you should get a heading of about 35°. Second, to find the azimuth, place a protractor along the meridian, with the center point at the intersection with the constructed line, and read from the protractor the angle between the meridian and the line. It is about 31°, as shown. But, because the declination is 4° west of true north, the grid line, the heading on the compass would be 35°. You can see why it is 31° + 4°: the compass north has actually been turned counterclockwise from the map when it was oriented; therefore, the compass reading over the line has moved from 31° to 35°.

L = 31°

Mapped, edited, and published by the Geological Survey

Control by USGS and USC&GS

Topography from aerial photographs by photogrammetric methods
Aerial photographs taken 1952. Field check 1960

Polyconic projection. 1927 North American datum
10,000-foot grid based on Ohio coordinate system, north zone
1000-meter Universal Transverse Mercator grid ticks,
zone 17, shown in blue

Fine red dashed lines indicate selected fence and field lines where generally visible on aerial photographs. This information is unchecked

Land lines within Congress Lands North of Old Seven Ranges based on Ohio River Base. Land lines within Connecticut Western Reserve established by private subdivision

Area covered by dashed light blue pattern is subject to controlled inundation to 1034 feet

TRUE NORTH
MAGNETIC NORTH
APPROXIMATE MEAN DECLINATION, 1960

Now, with the map oriented, the compass needle and north marker lined up, and the compass centered (as in the first procedure) on the point of meridian/constructed line intersection, lift the compass without turning it and slide out the map. Set the compass down. You now need only to sight from the center of the compass, down the 35° imaginary line, off into the distance and to find some outstanding object in the same line. If you are inside a building, obviously you cannot see a clear line of physical objects to follow for a reasonable period of time; but outdoors you might spot a building, a tree, a hill. Walk to that point, then line up the compass needle with the north mark, sight again along 35°, pick another object, and walk to that point. By this stepwise procedure, you will follow the magnetic azimuth to the intersection of French and Paris Avenues, all without a map. Incidentally, if you then wished to reverse your direction, simply add 180° to 35°, a so-called "back azimuth," to get a return heading of 215°.

In similar fashion, you can take compass sightings and then plot them later on your map (see procedure below). For instance, while taking the previous heading, you might observe a feature or something near a feature that you wish to map. If you know your distance by pacing from the starting point at Church Campground, write that down and "shoot an azimuth," i.e., align the compass needle with the north mark and sight across the center of the compass to the object (without turning the compass) and note the degree marker through which an imaginary line runs from the center of the compass to the object. Write that number down. Advance toward the French and Paris Avenues intersection a known distance and shoot a second azimuth. When you return to your map, orient it, place the compass at the distance you were when you made the two observations, and draw lines from the compass center through the degree mark that you noted. It is simpler and more accurately done with a compass. Repeat at the second distance. The two lines will intersect on the map at the place which represents the actual position of the object you spotted in the field.

To make your own study map, and from this study map to build a three-dimensional model as described in the audio-visual, first draw a larger-scale study map from

the small-scale USGS topographic map. You can do this by photographing it, projecting the negative on a plain piece of paper, and then tracing the enlarged section of your study area onto the paper. Or, you can cut out the topographic section which contains your study area, make a transparency, and project that onto paper via an overhead projector.

A third method is to draw the study area freehand. An enlargement of Walsfeld Lake in Rockford, Minnesota, 1:24,000 to 1:3,960 follows this page. Lay the acetate sheet (from Appendix II) over your study area. In the case of a 1:24,000 topographic map, use the lower of the two etched grids. With a fine felt-tip pen ink onto the 16 squares a direct tracing of the topographic map features. Then, draw the same features freehand in the 16 larger squares on the appended "Base Map Grid." Some information is given about the ratio of topographic to base map dimensions, but clearly you can make your own scale map. Obviously, the "base map grid" could be much larger squares, and the entire study area map might then become the size of a tabletop: a suitable size for a larger, three-dimensional model.

Once you have drawn the study map, you can enter observations of the type made <u>en route</u> from the Church Campground to the French and Paris Avenues intersection. Eventually, your study map will look similar to that which became a three-dimensional model in the audio-visual. No doubt your math teacher would be interested in working out with you some of the map projection ratios and conversions of units (feet, meters, acres, etc.).

With these few basic concepts and a few hours of practice, you can quickly become quite skilled at using both map and compass. There are a great many ways to form games, hunts, and special field trips which are structured about map and compass skills. These are documented in an appendix to the teacher's complement to this audio-visual unit and are the basis for Kjellstrom's book. Experience will help you build the map model described in the audio-visuals and, in turn, that will facilitate

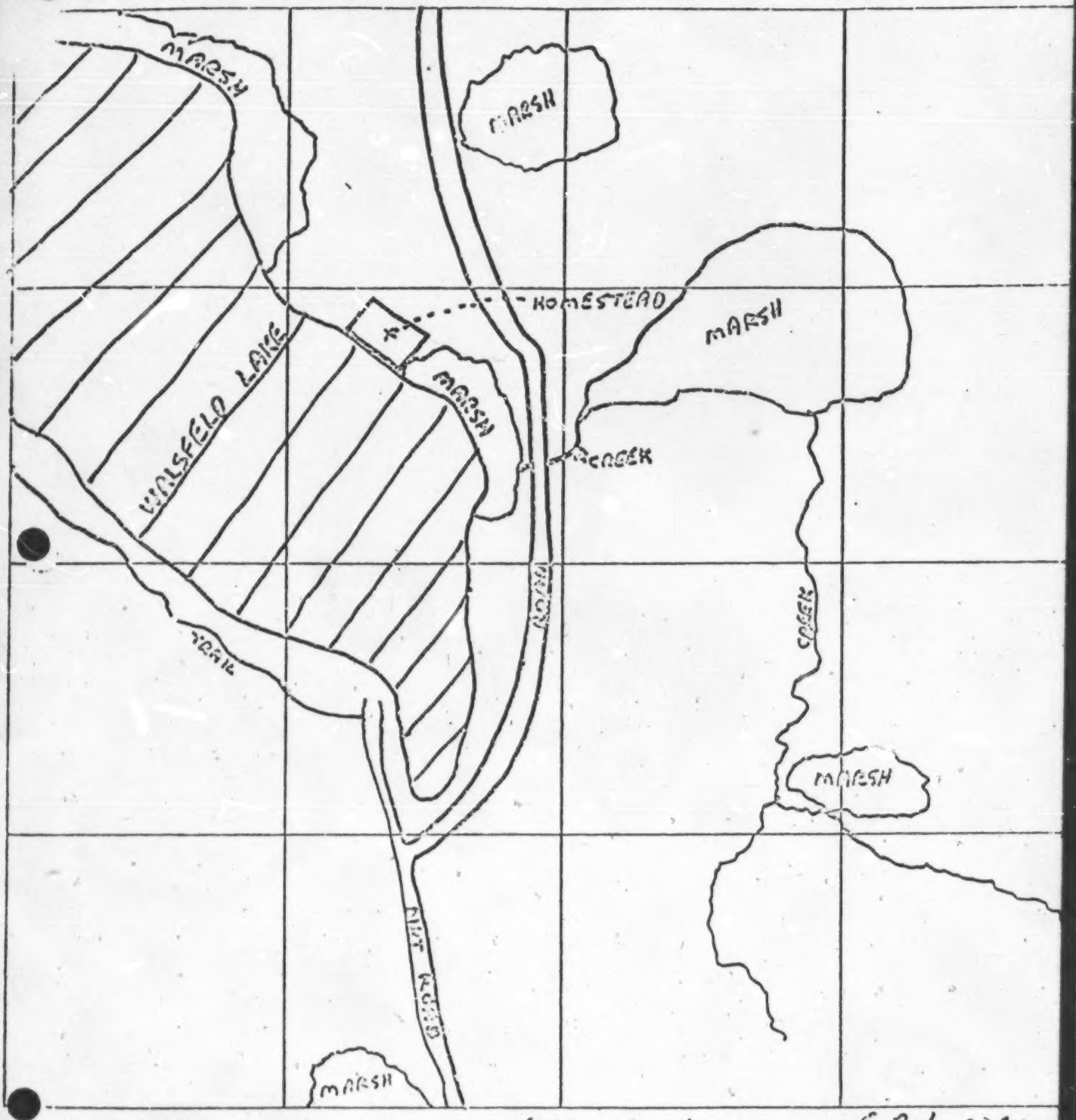
the reporting and analysis of data collected from your watershed study.

A reference is suggested for you or your school or local library. It is a classic in the field, highly readable--overall an excellent authority:

Greenhood, David. Mapping Chicago, Illinois: University of Chicago Press, 1975.

BASE MAP GRID

is should be used as an expanded base map. Distinctive physical features ould be transfered from the topographical map to this map with the aid of e appropriate acetate overlay grid.
key to any special symbols should be provided on the back of this sheet.



State ILLINOIS Quadrat Map ROCKFORD 15 min. Surveyor G.A. LITTLEFIELD
Site Name WALSFELD LAKE County WINNEBAGO
Latitude-Longitude of the Southwest corner of this map [illegible]

Each small square represents 10 acres and is 660 feet on a side. The scale of this map is 1:3,960.

BIBLIOGRAPHY

Kjellstrom, Bjorn. Be Expert with Map & Compass: The "Orienteering" Handbook. New York: Charles Scribner's Sons, 1975.

OTHER WORKS CONSULTED

U. S. Geological Survey. "Limaville Quadrangle, Ohio, 7.5 Minute Series (Topographic)." Washington, D. C.: U. S. Dept. of the Interior Geological Survey, 1960.

APPENDIX

I A. Silva Hand Compasses

B. Silva Compass Retail Prices

II A. Acetate Overlay Grid

B. Base Map Grid

C. Example

Silva Hand Compasses

Silva Polaris®
type 7

The Polaris is the most popular model in the Silva line for schools, Scout groups and beginners who need a good basic instructional compass at a modest price. Offers Silva quality construction and performance with liquid filled needle action that stops from full swing in just four seconds. Base plate contains inch scale on front and millimeter scale on side. Both housing and base plate are transparent for easy map use. Complete instructions included.

Size 2" x 3" Weight 1 oz.

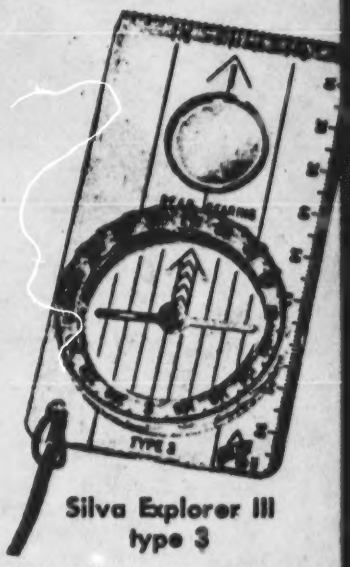
Retail $5.25

Silva Explorer III
type 3NL

Similar to the Type 7, but with added features for those who use maps more extensively. The Type 3 NL has liquid filled needle action with transparent housing and protractor. The longer protractor contains built in magnifying glass for reading detailed maps. Base plate has inch scale on front and millimeter scale on side. Complete instructions included.

Size 2-1/8" x 4" Weight 1-1/2 oz.

Retail $7.50



Silva Explorer III
type 3

Contains all the features of the Type 3 compass and more! It has luminous po for night use and comes complete with yard for easy carrying. Although competiti priced, the Type 3 contains features fo only in more expensive map models. Ne rests on sapphire jeweled bearing in liq filled transparent housing. Transparent b plate contains built-in magnifying glass inch scale on end and millimeter scale side. Complete instructions included.

Size 2-1/8" x 4" Weight 1-1/2 oz.

Silva Ranger
type 15

Used and approved by foresters, geologists, surveyors, scientific explorers, sportsmen and others demanding accuracy, speed and utility. Appraised by many as the world's finest hand compass. Army model in several countries. Liquid filled transparent housing and protractor plate. Highly magnetized needle set on sapphire jeweled bearing. Luminous points and sighting mirror. Built-in mechanism to adjust for magnetic declination. Inch scale on one side and millimeter scale on other side of base plate. Complete instructions included.

Size 2-1/2" x 4" Weight 3 oz.

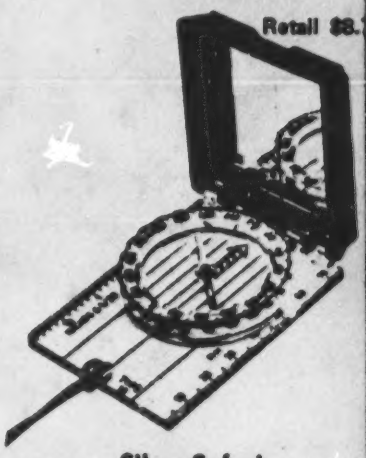
Retail $26.00

Silva Explorer I
type Is

User has choice of four total map scales – inch, millimeter, 1:24,000 and 1:20,000. The Typs IS is a professional quality, precision compass with liquid filled transparent housing and protractor base for those who use maps regularly. Needle resting on sapphire jeweled bearing in large metal housing with highly visible 2 degree graduations makes this model extremely accurate. Other features include magnifying glass for reading detailed maps, luminous points for night use, and rubber feet to prevent skidding when adjusting on map. Graduated 0-360°. Complete instructions included.

Size 2-3/8" x 5" Weight 2 oz.

Retail $19.50



Silva Safari
type 16

A compact compass with the same sighti arrangement as the Silva Type 15 Rang Designed for the outdoorsman who wants economically priced compass with spe sighting device for determining his bearin Mirror cover protects the capsule. Mirror also be used as an emergency reflector. Liq filled transparent housing and base plate w inch and millimeter scales makes this mo easy to use with maps. Contains lumino points for night work. Complete instructio included.

Size closed 2" x 3" Weight 2 oz.

Retail $17.

Silva Hand Compasses

Silva Huntsman® type 23

Designed specifically for sportsmen and women. Combines compass with protractor in compact design that allows user to keep both hands free. It can also be conveniently carried in pants or shirt pocket. Silva quality construction with rugged base plate. Capsule is liquid filled and transparent for map use. Base plate folds over for easy carrying and use as a sun watch. Complete instructions included.

Size open 4-1/2" x 1-1/2"
Closed 2" x 1-1/2" Weight 3/4 oz.

Retail $10.95

Silva Orienteering® type 4s/22

Popular compass for the exciting sport of orienteering. Contains all basic Silva features - transparent housing and protractor for map use, luminous points, and sapphire jeweled bearing. Includes four interchangeable scales - 1:20,000, 1:24,000, inch and millimeter. Also large magnifying glass for detailed map reading and rubber feet for non-skidding on maps. Size 2-3/8" x 5" Weight 2 oz.

Silva Step Counter Type 22. (As shown on Type 4S/22 compass) available seperately.

Retail $15.50

Silva Voyager type 2

The Type 2 has been redesigned to offer larger compass for map use, but still r tain the economical plastic housing. will also include an aluminum ring (n shown) graduated in mills that snaps ov plastic housing. The new Type 2 also fe tures 1:20,000, 1:24,000, inch and mil meter interchangeable scales. Contai larger magnifying glass for detailed m reading and luminous points for night u Transparent housing and protractor wi sapphire jeweled bearing. Graduated rin of 0-360 degrees and 6400 mills.

Size 2-3/8" x 4-3/8" Weight 1-1/2

Retail $15.

Silva Prospector type 25

The Type 25 is a precision made, compact sighting compass designed for professional or sports use. It closes into a small box to protect liquid filled capsule and makes it easy to carry anywhere. Includes built-in declination adjustment and luminous points for night use. Comes in attractive simulated wood grain package. Complete instructions included.

Size 1-7/8" x 2-5/8" Weight 4 oz.

Retail $27.50

Silva Wrist type 4w

This Type 4W compass is equipped with wide wristband so it can be worn directly over wrist or sleeve of outside clothing to leave both hands free. Housing is liquid filled and has the same features as the Type 4S/22 capsule. Capsule is interchangeable with the 4S/22 base plate for map plotting.

Retail $14.00

"Be Expert With Map and Compass"

Bjorn Kjellstrom

New Revised Edition! The most popul book on the subject of map & compa use now nearly twice as large with updat chapters and illustrations. This book pr vides a series of projects and exercis whereby the inexperienced person c easily train himself. Contains 22 and 126 illustrations with step-by-st instructions in map and compass us Also included is a training map, practici compass, and practicing protractor. T book has been acclaimed by individua scout leaders, and educators as the b book on the subject.

Retail $6.

SILVA COMPASS RETAIL PRICES
Effective January 1, 1977

COMPASSES*

1	Explorer I	$ 19.50
1 TD	Explorer I	22.00
1 TDQ	Explorer I	22.00
2	Voyager	15.00
3	Explorer III	8.75
3 NL	Explorer III	7.50
4 W	Wrist	14.00
4 D	Underwater	16.50
4 S/22	Orienteering	15.50
7	Polaris	5.25
15 TD	Ranger	25.00
15 TDQ	Ranger	25.00
15 TDCL	Ranger	28.00
15 TDCLQ	Ranger	28.00
16	Safari	17.50
16 B	Braille	19.50
23	Huntsman	10.95
25	Prospector	27.50
22	Step Recorder	3.00

LEATHER CASES*

No. 1	5.25
No. 15	5.25
No. 20	4.50
No. 7	2.50

GIFT SETS*

3-23	Huntsman	17.90
B-7	Polaris	12.20
4-G	Orienteering	20.00

CLINIC KITS***

Map & Compass Clinic	30.00
Filmstrip	60.00
Parks Orienteering Kit	10.00

MAP CASES*

No. 400	5.25
No. 404	1.75
No. 421	2.25

TRAINING AIDS*

Demonstrator Compass	7.75
Competitive Compass Game	.75
Metric Compet. Comp Game	1.00
Schoolyard Compass Game	1.00
Practicing Compass	.15
Practicing Protractor	.05
Training Map	.25
Questionnaires	.25
Map Symbol Relay Game	1.00
Directions, Directions	.30
Map Memory Relay Game	2.50

BOOKS*

"Be Expert With Map & Compass"	$ 6.95
"Orienteering" (J. Disley	3.95
"Orienteering-An Aid To Training"	4.50
"Know The Game - Orienteering"	2.25
"Know The Game - Map Reading"	2.25
"Your Way With Map & Compass (Teacher's)	3.50
"Your Way With Map & Compass (Student's)	2.75
"Ski Orienteering"	.50
"Teaching Orienteering"	2.95
"Learn Orienteering"	.25
"Trim Orienteering"	1.00
"Map Making for Orienteers"	2.50

PEDOMETER, ALTIMETERS*

#29 Pedometer	14.95
#30 Pedometer	11.95
#1040 Altimeter/Barometer	13.95

ORIENTEERING MEET EQUIPMENT***

Cardboard Control Station Markers	6.00/do
Nylon Control Station Markers	2.00/ea
Control Clippers (Specify A or B)	17.50/se
Result Frames	19.00/se
Orienteering Bibs (Specify no. & color)	22.50/se
Scorecards (Specify color)	.01/ea
Orienteering Tote Bag	7.95

ORIENTEERING CLOTHING**

Running Suit	22.00
SILVA T-Shirt	4.95
#26 Shoes	17.50
#27 Shoes	17.50
#28 Boots	17.00
Orienteering Socks	7.00
Knickers	11.00
Pull-over	7.00

Compass Carrying Case	10.00

Schools and Camps receive the following discounts on indicated items if sent in on formal purchase order:

* 20%
** 10%
*** NO DISCOUNT

SILVA Co.
2466 N. St. Rd. 39
LA PORTE, INDIANA 46350
Phone: 219-362-9596

OVERLAY GRIDS

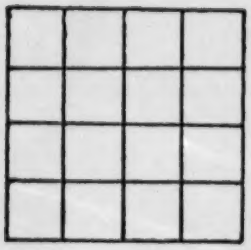
These overlay grids are to be used with TNC base map grid sheets. Overlay grids are used to assist with the transfer and expansion of baseline information from topographical maps.
The overlay grids which are provided are for use with 1:24,000 and 1:62,500 (7½ and 15 minute) quad maps. If available maps are scaled differently you may construct your own overlay grids using the formula:

$$\text{the side of each grid square (in inches)} = \frac{7920}{\text{scale of map.}}$$

For example with a 1:6000 scale map the ratio would be 7920/6000 i.e. the side of each grid square would be 1.32 inches in length. Other useful sizes include 1:90,000 scale where grid size would be 0.09 x 0.09 inches.

Use with 1:62,500 maps.

Use with 1:24,000 maps.



BASE MAP GRID

This should be used as an expanded base map. Distinctive physical features should be transfered from the topographical map to this map with the aid of e appropriate acetate overlay grid.
key to any special symbols should be provided on the back of this sheet.

State_____ Quadrat Map_____ Surveyor_____
Site Name_____ County_____
Latitude-Longitude of the Southwest corner of this map_____N_____W

Each small square represents 10 acres and is 660 feet on a side. The scale of this map is 1:3,960.

APPENDIX — State Water Pollution Control Agencies

Department of Environmental Conservation
Division of Air and Water Quality Control
Juneau, Alaska 99801
Phone: 907-586-3371

State Water Improvement Commission
State Office Building
Montgomery, Alabama 36104
Phone: 205-269-7971

Environmental Quality Commission
Government of American Samoa
Office of the Governor
Pago Pago, American Samoa 96920

Environmental Health Service
Division of Water Pollution Control
Hayden Plaza West
4019 North 33rd Avenue
Phoenix, Arizona 85017
Phone: 602-271-4636

Department of Pollution Control and Ecology
8001 National Drive
Little Rock, Arkansas 72209
Phone: 501-371-1701

Water Resources Control Board
1416 Ninth Street
Sacramento, California 95814
Phone 916-445-3083

Department of Public Health
Water Pollution Control Division
4210 East 11th Avenue
Denver, Colorado 80220
Phone: 303-388-6111

Department of Environmental Protection
Water Compliance Unit
State Office Building
Hartford, Connecticut 06115
Phone: 203-566-3345

Department of Natural Resources and Environmental Control
Division of Environmental Control
Dover, Delaware 19901
Phone: 302-678-4765

D.C. Department of Environmental Services
Bureau of Air, Water, and Noise
25 K Street NE
Washington, D.C. 20002
Phone: 202-629-3748

State Department of Pollution Control
2562 Executive Center Circle East
Tallahassee, Florida 32301
Phone: 904-488-4805

Department of Natural Resources
Environmental Protection Division
47 Trinity Avenue S.W.
Atlanta, Georgia 30334
Phone: 404-656-4713

Environmental Protection Agency
Government of Guam
P. O. Box 2999
Agana, Guam 96910
Phone: 749-9903

State Department of Health
Environmental Health Division
P. O. Box 3378
Honolulu, Hawaii 96801
Phone: 808-548-4139

Department of Environmental Protection and Health
Air and Water Programs
Boise, Idaho 83701
Phone: 208-384-2390

Environmental Protection Agency
Land and Water Pollution Division
2200 Churchill Road
Springfield, Illinois 62706
Phone: 217-525-4760

Stream Pollution Control Board
1330 West Michigan Street
Indianapolis, Indiana 46206
Phone: 317-633-4420

Department of Environmental Quality
Water Quality Management
Lucas State Office Building
Des Moines, Iowa 50319
Phone: 515-281-3145

State Department of Health
Division of Environmental Health
Water Quality Section
535 Kansas Avenue
Topeka, Kansas 66603
Phone: 913-296-5621

Department of Natural Resources and Environmental Protection
Division of Water
275 East Main Street
Frankfort, Kentucky 40601
Phone: 502-564-3410

Stream Control Commission
P. O. Drawer FC
University Station
Baton Rouge, Louisiana 70803

Department of Environmental Protection
Bureau of Water Pollution Control
State House
Augusta, Maine 04330
Phone: 207-289-2591

Environmental Health Administration
Division of Water and Sewerage
610 North Howard Street
Baltimore, Maryland 21201
Phone: 301-383-2760

Department of Natural Resources
Division of Water Pollution Control
100 Cambridge Street
Boston, Massachusetts 02202
Phone: 617-727-3855

Water Resources Commission
Stevens T. Mason Building
Station A
Lansing, Michigan 48926
Phone: 517-373-1960

Pollution Control Agency
Division of Water Quality
717 Delaware Street, S.E.
Minneapolis, Minnesota 55440
Phone: 612 296-5318

State Air and Water Pollution Control Commission
Division of Water Pollution Control
P. O. Box 827
Jackson, Mississippi 39205
Phone: 601 354-6781

Clean Water Commission
P. O. Box 154
Jefferson City, Missouri 65101
Phone: 314 751 3241

Department of Health and Environmental Science
Water Quality Bureau
Helena, Montana 59601
Phone: 406-449-2407

Department of Environmental Control
Water Pollution Control
1420 P Street
Lincoln, Nebraska 68509
Phone: 402-471-2186

Department of Health, Welfare and Rehabilitation
Bureau of Environmental Health
201 S. Fall Street
Carson City, Nevada 89701
Phone: 702-882-7458

Water Supply and Pollution Control Commission
105 Loudon Street, Pleasant Park
Concord, New Hampshire 03301
Phone: 603-271-3502

Department of Environmental Protection
P. O. Box 1390
Trenton, New Jersey 08625
Phone: 609-292-2885

Environmental Improvement Agency
Water Quality Section
Santa Fe, New Mexico 87501
Phone: 505 827-2373

Department of Environmental Conservation
Albany, New York 12201
Phone: 518 457-3446

State Department of Natural and Economic Resources
Office of Water and Air Resources
Division of Water Quality
P. O. Box 27687
Raleigh, North Carolina 27611
Phone: 919 829 4740

State Department of Health
Division of Water Supply and Pollution Control
Bismarck, North Dakota 58501
Phone: 701-224-2386

Environmental Protection Agency
361 East Broad Street—Room 339
Columbus, Ohio 43216
Phone: 614-466-7385

Deputy Commissioner for Environmental Health
Department of Health
3400 North Eastern Avenue
Oklahoma City, Oklahoma 73105
Phone: 405-427-6561

Department of Environmental Quality
Administration of Water Quality
1400 S.W. Fifth Avenue
Portland, Oregon 97201
Phone: 503-229-5696

Bureau of Water Quality Management
Department of Environmental Resources
Harrisburg, Pennsylvania 17120
Phone: 717-787-2666

Environmental Quality Board
c/o Solid Waste Branch
P. O. Box 11785
Santurce, Puerto Rico 00910

Division of Water Supply and Pollution Control
Environmental Health Services
R. I. Health Building Room 209
Providence, Rhode Island 02908
Phone: 401-277-2234

Water Pollution Control Division
State Pollution Control Authority
2600 Bull Street
Columbia, South Carolina 29201
Phone: 803-758 2913

Department of Environmental Protection
Room 413, Office Building 2,
Pierre, South Dakota 57501
Phone: 605 224 3181

Department of Public Health
Water Quality Control Division
621 Cordell Hull Building
Sixth Avenue, North
Nashville, Tennessee 37219
Phone: 615-741-2275

Water Quality Board
P. O. Box 13246
Capitol Station
Austin, Texas 78711
Phone: 512-475 2651

Department of Health Services
Division of Environmental Health
Trust Territory of the Pacific Islands
Saipan, Mariana Islands 96950

Bureau of Environmental Health
Water Quality Section
44 Medical Drive
Salt Lake City, Utah 84113
Phone: 801-328-6146

Agency of Environmental Conservation
Montpelier, Vermont 05602
Phone: 802-828 3357

State Water Control Board
P. O. Box 11143
Richmond, Virginia 23230
Phone: 804-770-2241

Commissioner of Health
Department of Health
P. O. Box 1442
Charlotte Amalie
St. Thomas, Virgin Islands 00801
Phone: 809-774-1321

Department of Ecology
Olympia, Washington 98501
Phone: 206-753-2800

Division of Water Resources
Department of Natural Resources
1201 Greenbrier Street
Charleston, West Virginia 25311
Phone: 304-345-2107

Department of Natural Resources
Division of Environmental Protection
Madison, Wisconsin 53701
Phone: 608 266-2747

Department of Health and Social Services
Sanitary Engineering Services Department
State Office Building
Cheyenne, Wyoming 82001
Phone: 307-777-7513